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Simposio internazionale sui gas residui nei tubi elettronici e in sistemi similari ad alto vuoto

Como, 23-25 Settembre 1959

Parole inaugurali

DI

GIOVANNI POLVANI

Presidente della Società Italiana di Fisica

Questo Simposio ha una sua piccola storia che credo convenga raccontare. Comincerò col dire che il merito dell'idea di esso spetta del tutto all'ing. PAOLO DELLA PORTA, Consigliere delegato della Società Apparecchi Elettrici Scientifici e della Edwards Italiana, il quale, insieme col prof. ANTONIO NASINI venne, or sono quasi due anni, a propormi di interessare la Società Italiana di Fisica a un Simposio sui gas residui nei tubi elettronici e in generale in quelli ad alta rarefazione.

La proposta, portata da me in Consiglio di Società, non trovò, a dire il vero, molto favore: fu osservato che il Simposio, interessando soprattutto gli industriali, si sarebbe configurato troppo diversamente da quelli tradizionali fino ad allora svolti, i quali invece avevano interessato soprattutto i fisici, e che l'argomento di Fisica tecnologica o, per meglio dire, di tecnica fisica proprio del Simposio in questione sarebbe stato troppo lontano da quelli di Fisica fondamentale che fino ad allora avevano formato oggetto delle nostre riunioni.

Come si vede, anche il nostro Consiglio, nonostante abbia fama di vivacità

nel prendere e sviluppare nuove iniziative si era reso troppo legato alla tradizione. Brutto segno!

Ma poi, un po' riparlando della cosa coll'ing. DELLA PORTA, un po' ridiscutendone in Consiglio, questo avvenne: che quelle ragioni che sembravano contrarie a che la Società facesse sue le proposte avanzate, finirono per trasformarsi in favorevoli, tanto da persuadere essere opportuno che la Società nei suoi convegni si rivolgesse, almeno qualche volta, anche a questioni di Fisica non fondamentale e riunisse non solo fisici puri, ma anche tecnologi e gli industriali stessi che dalla soluzione più o meno opportuna o più o meno abile di problemi tecnici traggono un progresso alla loro produzione. E sinceramente tutti riconoscemmo che ottima occasione a questo superamento della nostra tradizione, era quella che l'ing. DELLA PORTA offriva con la sua proposta. Dobbiamo dunque essere, come siamo, molto riconoscenti a lui, dinamico, saggio e preziosissimo collaboratore.

Naturalmente, una volta preso l'aire, la Società si è rifatta della sua primitiva tardità, e all'iniziativa ha dato tutto il più largo appoggio.

All'attuazione hanno collaborato i membri del Comitato organizzatore, in particolare i due segretari del Convegno, cioè il prof. EMILIO GATTI e l'ing. DELLA PORTA.

A tutti quelli che ho nominato i più profondi ringraziamenti da parte della Società tutta, del Consiglio e mia.

Ugualmente porgiamo espressioni di viva gratitudine ai vari membri del Comitato d'Onore e particolarmente a Sua Eccellenza il Prefetto di Como, per il pregio maggiore che essi con la loro adesione han dato e dànno al Simposio. Ugualmente al Consiglio Nazionale delle Ricerche e al suo Presidente, prof. F. GIORDANI, e alla Organizzazione Internazionale della Scienza e della Tecnologia del vuoto e al suo Presidente, prof. E. THOMAS, per aver dato i loro auspici e il loro patrocinio; all'Amministrazione Provinciale di Como e al suo Presidente, dott. A. ROSSI, e all'Amministrazione Comunale di Como e al Signor Sindaco. comm. L. GELPI per la cortese e premurosa ospitalità; all'Ente Villa Monastero e al suo Presidente, avv. G. BOSISIO, per avere accolto questa manifestazione tra le attività dell'Ente; e all'Ente Provinciale per il Turismo di Como e al suo Presidente, comm. G. RUSSO, per l'aiuto dato nel risolvere il difficile problema degli alloggi.

E ringraziamenti vivissimi debbo porgere anche alla Società SAES di Milano per l'aiuto dato nell'organizzare il Simposio, e alla Pergamon Press per aver assunto la pubblicazione dei *Rendiconti*.

Ma è ovvio, infine che il ringraziamento più vivo va agli attori di scena — per così dire — cioè a tutti i partecipanti al Simposio, specie a quelli che presentano relazioni, memorie, note relative alle proprie ricerche e ai propri studi. Senza di loro il Simposio non si sarebbe fatto: grazie a loro dunque di cuore per avere accolto l'invito della nostra Società a intervenire a questo Simposio.

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Il mio discorso potrebbe chiudersi qui senza entrare in questioni scientifico-tecniche relative all'argomento trattato. Tuttavia a questo proposito vorrei fare qualche accenno del tutto generale.

Se il problema di fare il vuoto in un recipiente è vecchio di più di tre secoli, esso è diventato particolarmente vivo e — direi — giovane in questo ultimo settantennio, da quando cioè cominciarono gli studi sistematici delle proprietà delle superficie dei corpi nel vuoto e in particolare della complessa emissione molecolare, atomica ed elettrica cui possono dar luogo dipendentemente dalla temperatura, dalla « storia » della superficie stessa, dalle condizioni esterne ecc.

Negli ultimi tempi l'ottenimento di alte rarefazioni fu sensibilmente migliorato aggiungendo ai mezzi esterni offerti dalle pompe meccaniche o a diffusione o a condensazione, i mezzi interni offerti da procedimenti chimici, in particolare dal getter a proposito del quale ci è gradito ricordare che tra i pionieri di questa tecnica fu un italiano il MALIGNANI.

Il problema si è poi — diciamo così — inasprito da quando ai comuni tubi elettronici si richiese un funzionamento straordinariamente lungo, straordinariamente sicuro, straordinariamente costante: tre caratteristiche che sempre più appaiono necessarie e da doversi ulteriormente esaltare per corrispondere alle necessità imposte da alcune applicazioni che di giorno in giorno vanno sempre più diffondendosi e assumendo parti sempre più importanti nel comune tecnicismo moderno.

Il problema di *fare il vuoto* si associa a quello, forse ancor più difficile, di *mantenere il vuoto*. Si ha infatti un bel fare la rarefazione più spinta per esempio in una comune valvola radio se non si provvede anche a che le superficie dei corpi che limitano la zona rarefatta non emettano gas; o, se ne emettono, non si provvede alla loro continua eliminazione. Problema questo che si esaspera poi nel caso di tubi di dimensioni minime, a causa della elevata temperatura di tutte le parti di essi. Quindi, come ben si comprende, il problema della costruzione di valvole o più in generale di recipienti a rarefazione ultraspinta che siano dotati spiccatamente delle caratteristiche suddette, tocca tutta una gamma di tecnologie estremamente complesse e raffinate sia per l'ottenimento della rarefazione iniziale, sia per l'uso di materiali da costruzione che assicurino che la rarefazione iniziale non venga sensibilmente a mutare. Questioni affini a queste alle quali ho accennato, presentano, in forma più generale i tubi con atmosfera controllata.

Ora chi scorra il programma del Simposio, denso di comunicazioni e di relazioni, può facilmente sorprendere come i problemi fondamentali relativi all'oggetto del nostro Simposio abbiano tutti dato origine a numerosi interventi, molti dei quali si preannunciano assai notevoli, di autorevoli fisici e tecno-

logi del vuoto. Io penso quindi che questo Simposio avrà — certo, indubbiamente — una notevole importanza per i contributi che porterà alla conoscenza delle questioni trattate; e penso anche — è verità lapalissiana — che gli sviluppi continui della scienza e della tecnica, obbligheranno in progresso di tempo ad altre riunioni simili a questa. La quale quindi, dato che è stata la prima del genere, potrebbe fregiarsi dell'aggettivo che indubbiamente le spetta: cioè di « Primo » Simposio Internazionale sui gas residui ecc., ecc. E qui si potrebbe anche fissare fin d'ora dove e quando tenere il secondo Simposio, e così via.

Inoltre, scendendo a un ordine di questioni diverse, più speciale e nostro italiano, penso anche, infine, che questo Simposio potrebbe offrire lo spunto, l'occasione, l'incentivo a chi si occupa nel nostro Paese di problemi del vuoto, per far sorgere un'associazione italiana, un gruppo italiano — si chiami come si vuole — di fisici, tecnologi e specialisti del vuoto.

Con questo augurio, e con quello più generale che i lavori che in questi tre giorni di riunioni si svolgeranno nell'ospitalissima Como, abbiano il migliore successo, dichiaro aperto il I Simposio Internazionale sui gas residui nei tubi elettronici e in sistemi similari ad alto vuoto.

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* Queste « Parole inaugurali » furono, dopo la mia lettura, ripetute in inglese dall'ing. G. Rochat, al quale mi è gradito porgere i ringraziamenti più vivi per questa sua cortesia.

Sunti delle comunicazioni presentate al Simposio

E. Argano. Vedi pag. 307 e 308.

J. Bailleul-Langlais (*Suresnes*). – **Les getters au baryum dans les tubes électroniques de réception.**

Les deux rôles que l'on prête traditionnellement aux getters sont examinés en étudiant les variations de pression au sein d'un tube: 1. Au cours du flash. 2. Au cours du traitement et de la vie de celui-ci. On montre la très grande importance du dégazage des getters sur pompe avant coupe et flash, ainsi que l'influence du chauffage, du débit et des périodes de stock sur l'évolution de la pression. Après avoir rappelé les divers modes d'absorption des gaz à chaud et à froid, quelques cas « pathologiques » accidentels sont étudiés. On indique en particulier, comment l'examen de la couleur de dépots anormaux de baryum peut aider dans la recherche des causes de défectuosité. Quelques conclusions très pratiques sont tirées de toute cette étude.

F. A. Baker and T. A. Giorgi (*London*). – **The Applicability of the Omegatron to Continuous Analysis of Residual Gases.**

An experimental study is described in which residual gases were analysed by means of a cyclotron resonance mass spectrometer of the omegatron type. Analysis was continuous before, during and after both (*a*) ion pumping with a Bayard-Alpert pattern hot-cathode gauge and (*b*) the dispersal of a barium getter. Results are more extensive than any published hitherto and are presented both as mass spectra and the variation of gas constitution with time throughout each stage of the above operations. The study illustrates the potentialities of the omegatron as a tool for solving many problems existing in vacuum technology. In particular, by regarding the Bayard-Alpert pattern gauge as an electron tube, it is shown that the omegatron is well suited to the analysis of residual gases during the manufacture and life of tubes.

E. Biolley (*Lyon*). – **De l'utilisation des getters dans les tubes à rayons cathodiques de télévision.**

Pour améliorer sensiblement la brillance des images, les fabricants ont été amenés depuis quelques années à aluminiser les écrans de tubes cathodiques de télévision. Toutefois, la surépaisseur d'aluminium au centre de l'écran est visible à tension anodique réduite. C'est pour ce motif que la valeur minimale de la tension d'utilisation a été fixée pour chaque type. Il est cependant aisé pour le fabricant de rester dans les limites imposées à condition toutefois que le dépôt de baryum getter, de poids atomique plus élevé, plus opaque encore que le film d'aluminium ne vienne pas accentuer le défaut occasionné par la mauvaise répartition de celui-ci, perturbant ainsi l'uniformité de couleur de l'écran à tension minimale admise. Il convient pour cela de diriger au moment de la vaporisation les molécules de baryum getter afin qu'elles aillent se déposer ailleurs que sur l'écran. Une solution a été trouvée par la un fabriquant italien qui fournit un getter annulaire à déflecteur très efficace. Il suffira, pour en faire un emploi rationnel, de prendre quelques précautions, sans lesquelles le remède risquerait d'être pire que le mal. Au cours de cette communication seront fournies quelques séries de résultats comparatifs illustrant parfaitement cette théorie.

Th. H. Briggs (*Norristown, Pa.*). – **Gas Effects on Cathode Emission.**

Emission capabilities of oxide cathodes have been studied for many years using techniques of increasing refinement. With the ASTM Standard diode it has been possible to detect significant differences between nickel base alloys and even between heats of these alloys. Results, however, have not been reproducible between laboratories, nor sufficiently sensitive for present-day needs. Study of data indicated the existence of an uncontrolled variable. This has been demonstrated to be gas which evolved slowly and in minute quantities. Gas accumulation in the cathode base metal has been measured. Gas liberation from grid and anode films has been shown to influence emission. Continuous clean-up of gas during tube operation has been shown beneficial. Experiments are being run with a variety of continuous getters, and with continuous pumping. In addition to longer electrical life, there is greater uniformity of cathode emission between readings. Important and unexpected influence upon cathode interface impedance has been found. It will be shown that several advances in tube performance, and simplifications in tube materials may be obtained through control of the micro-amounts of gas liberated continuously during tube life.

G. Calvi and R. Ricamo (*Catania*). – **Double Pirani Bridge Leak Detector.**

For leak detecting in a vacuum system, a device has recently been suggested founded on the measurement of the pressure drop in the suction pipes. As this pressure drop must be dependent on the leak entity, in the vessel under test, and on the resistance of the pipes, we have thought of changing the resistance of the pipes in such a way that

the sensitivity of the device as a leak detector can be regulated and its maximum investigated. The apparatus is made of a brass rod, about 20 cm long, grooved along its axis and having four lateral pieces, placed in pairs at an equal distance from the rod ends. Each of the four derivations has, placed in a suitable cell, PIRANI gauges which are connected to the axial bore of the rod. In the middle of this rod is inserted a throttle adjustable from outside, which allows, adjusting the light of the rod, to change within a wide range the pressure drop between rod ends and therefore the sensitivity of the device as a leak detector. The sensitivity can be increased by reducing the throttle light without a notable change in the device pumping speed and the pressure of the vessel under test until the aerodynamic resistance of the device canalization is small in comparison with the total resistance of the suction pipes. The PIRANI gauges mounted, as we have said, two by two on opposite sides of the throttle, are electrically connectded as a Wheatstone bridge and in such a way that those placed on the same side of the throttle form the opposite arms of the bridge. The filaments of the PIRANI gauges are made of four cylindrical « minimignon » lamps 160 V - 3 W, the bulbs of which have been opened. Such filaments have a cold resistance of 330 Ω. In order to bring such filaments to the PIRANI gauges working temperature, *i.e.* about 100 °C, they must carry a current of about 4 mA, therefore the bridge must be fed by a constant d.c. potential of about 4 volts. Under these conditions, and in vacuum, the resistance of the filaments reaches 440 Ω. As a bridge null-point indicator a galvanometer multiflex was employed, having a sensitivity of 1.2 mm/μV. The above device was connected to the pipe between the diffusion pump and the rotary pump. The maximum sensitivity of this first device was about 10^{-7} cm^3/s n. t. p. The sensitivity obtained by this very simple device and which can be improved, should be compared with the average sensitivity of the mass spectrometry leak detectors (10^{-9} cm^3/s n.t.p.). The apparatus has proved very useful for leak detecting on the VAN DE GRAAFF accelerator operating in this Centre.

M. G. CHARLTON, D. NEWSON and P. J. WHITCHURCH (*Mitcham Junction*). – **An Automatic Apparatus for the Testing of Getter Adsorption.**

Routine testing of getter films has in the past been carried out using dosing methods, which require the constant attention of an operator. An apparatus has therefore been developed which operates automatically, recording the uptake of gas and at the same time maintaining the gas pressure over the getter constant. The principle of operation is as follows. Pulses of gas enter the getter chamber from a reservoir through a special magnetic valve which is continuously and rapidly opened and closed. The ratio of time open to time closed is automatically controlled so as to maintain a constant pressure in the getter chamber. Control is exerted by a special switching circuit which continuously varies the ratio of interval on to interval off, according to the input signal. This signal is provided by the voltage across the meter in the getter chamber PIRANI gauge circuit. With a PIRANI gauge attached to the gas reservoir, a continuous record of pressure drop against time can be obtained with a potentiometer recorder. If a capillary tube and a high pressure PIRANI gauge are interposed between the getter chamber and the magnetic valve, the signal from this PIRANI gauge may be used to obtain a direct record of gettering rate against time. The apparatus has been used with carbon monoxide and hydrogen at getter chamber pressures of about 1 micron. There

is no limit in regard to the use of higher pressures, but with the present control circuit the use of lower pressures would lead to less satisfactory control, which at 1 micron pressure was never worse than $\pm$ 10%, and generally much better.

M. G. CHARLTON and F. H. SOUTHAM (*Mitcham Junction*). – **The Adsorption of Methane by Barium Films in the Presence of a Thermionic Current.**

The adsorption of methane at pressures of $7 \cdot 10^{-7}$ to $7 \cdot 10^{-6}$ Torr has been studied both in the presence and absence of a thermionic current drawn from a tungsten filament, using the capillary flow method of WAGENER, and maintaining the pressure over the barium film constant. The pumping speeds of barium films covering up to 160 cm^2 and up to 20 mg in weight under normal conditions were very small and were less than 5 cm^3/s at $1.5 \cdot 10^{-6}$ Torr. The presence of an incandescent tungsten filament caused a slight increase in pumping speed of the barium films of about $(10 \div 20)$ cm^3/s. Drawing an emission current from the filament appreciably increased the pumping speed of the getter, the increase amounting to $(70 \div 100)$ cm^3/s at $1.5 \cdot 10^{-6}$ Torr with a current of 5 mA. The pumping speed was independent of the area and weight of barium film but was approximately proportional to the thermionic current; it was almost independent of the pressure, up to $7 \cdot 10^{-6}$ Torr, and hence the adsorption rate (pumping speed $\times$ pressure) was roughly proportional to pressure. The results show that the adsorption rate on barium films of methane activated by electron impact is determined entirely by the frequency of electron-gas molecule collisions. It is not known wheter the active species consists entirely of ions or whether non-ionized radicals and molecules resulting from the decomposition of methane are involved.

R. H. COLLINS and Dr. J. C. TURNBULL (*Lancaster, Pa.*) – **Evolution and Absorption of Gases in Electron Tubes.**

Gas evolution effects in vacuum tubes have been determined using the gas collection method of Morrison [1], in which evolved gases in an operating tube are collected with a mercury pump, stored in its fore-vacuum system, and measured with a mass spectrometer after many hours operation of the tube. Also, by simultaneously leaking gases into the tube and using the same collection system, the speed of absorption of the tube for various gases has been determined. In this way the partial pressures of gases and their internal evolution and absorption rates in the operating tube were found. These techniques were applied to a practical vacuum tube, the 21CYP22 color kinescope. Typical partial pressures of gases determined during electrical operation of the tube were: hydrogen, 10^{-8} mm Hg, nitrogen (including a small fraction of carbon monoxide), 10^{-9} mm Hg, and oxygen, $2 \cdot 10^{-11}$ mm Hg. Oxygen is present only when the tube is scanned, and it is evolved by non-metallic bulb surfaces which are bombarded with high voltage electrons. Self absorption of the tube for oxygen is very rapid (pumping speed is 3000 liters per second). Thus oxygen partial pressure, during operation of this tube, is maintained at such a low level that there is no effect on performance of the oxide cathode.

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[1] J. MORRISON, « Gas Collection and Analysis System [Employed in Tube Problems », Vacuum Symposium Transactions (London, 1957).

S. H. Cross (*Harwell*). – **The System Design and the Choice of Materials for the « Nimrod » Vacuum System.**

The backbone of a proton synchrotron is the massive electro-magnet which keeps the protons in orbit. Economy and utility in the design of this in conjunction with the beam dynamics of the machine decide many physical constants of the vacuum system if optimum performance is to be obtained, and the scattering effect of the residual gas molecules on the proton beam determines the pressure at which the system must work. The dimensions of the vacuum vessel are thus determined; calculations relating duct size to pumping speed and gas evolution rate have been carried out and the results of these are presented. Pumping units using 60 cm diameter oil vapour diffusion pumps have been designed and are now being produced. Tests of the first ones show that they are capable of attaining ultimate pressures (with no gas load) of $3 \cdot 10^{-7}$ Torr. During investigations to discover the most suitable material with which to make the vacuum vessel, determinations of the gas evolution rates of various polymers have been carried out and certain of the epoxy resins with glass-fibre reinforcement are the best materials so far found, partly because of their high strength to volume ratio. Work has been done to show the effect that irradiation has on the mechanical strength and gas evolution rate of these materials. Techniques are being developed to produce laminates in the workshop which are free from voids that may cause leakage. The gas evolution rates obtained from these epoxy resins are higher than can be tolerated if the requisite operating pressure of 10^{-6}Torr is to be maintained in the vacuum vessel and it is necessary to mask the surface exposed to the vacuum in order to reduce the amount of gas evolved, a technique which has already been applied in the « Saturn » proton synchrotron at Saclay using stainless steel strips, but the different design parameters of « Nimrod » call for different techniques and considerable attention is being given to this.

W. Dahlke and H. J. Schütze (*Ulm*). – **Residual Gas Pressure in Electron Tubes.** Part I: Method of Measurements (*).

In order to determine the residual gas pressure in an electron tube its electrode system is circuited as ionization gauge. The positive current

$$I_+ = I_{\text{ion}} + I_{st} \tag{1}$$

collected by the ion collector is measured. This current consists of the ion current I_{ion} and a stray current I_{st}. Using Barkhausen's equation the gas pressure

$$p = \frac{1}{k_g} \frac{I_{\text{ion}}}{I_-} \tag{2}$$

is calculated from the ratio of the measured ion current I_{ion} and the electron current I_-. The gas ion constant k_g being independent of p is determined by calibration. Allowing a maximum error of 10% for pressure measurements a lower limit of measurable pressure

$$p_{\min} = 10 \frac{\Delta I_{\text{ion}}}{k_g I_-} \tag{3}$$

(*) As to Part II see H. J. Schütze and H. W. Ehlbeck.

is obtained. ΔI_{ion} represents the absolute value of the error of I_{ion} measurement. Equation (3) indicates that a large product of $k_g I_-$ is favorable for low values of p_{min}. The depedence of k_g on the geometry, the circuit and the operating conditions of the tube under test is discussed. For a pentode it is useful to operate the tube with the plate being ion collector. The stray current

$$I_{st} = I_+^0 + k_X I_- \tag{4}$$

is represented by a linear function of the electron current I_-. The term I_+^0 can be measured directly. It is identical with the collector current I_+, the electron current being zero. I_+^0 is composed generally of a leakage current, a photoelectric current due to illumination by light and a thermionic emission of the ion collector. The term $k_X I_-$ in equation (4) which is produced by photoelectric emission of the collector due to soft X-rays is determined by measuring the collector current I_+ at very low pressures. The photoelectric current is strongly dependent on the operating potentials. In a pentode for instance it may be suppressed rather perfectly using the plate as ion collector and supplying a suitable negative potential to the 3rd grid. Finally the gas pressure p and the pressure limit p_{min} are obtained by introducing into equations (2) and (3) the ion current

$$I_{ion} = I_+ - I_+^0 - k_X I_- \tag{5}$$

as function of measured quantities. A practical pressure measuring set using the differential method following equation (5) is described. Results are given for a broad band pentode, a power pentode and a television picture tube. The corresponding limits of pressure measurements are compiled in the following table.

Tube Type	EF 800	PL 36	AW 53-88
p_{min} Torr	5.10^{-9}	2.10^{-7}	$< 3.10^{-8}$

P. DELLA PORTA (*Milan*). – **Apparatus and Techniques for Measurements of the Adsorption of Gases by Evaporated Getters.**

The present work describes the apparatus and techniques used at the S.A.E.S. Research Laboratories to study the gettering action of evaporated barium films on different gases. During the past few years the sorption of gases by getters (evaporated or not) has been increasingly studied from a kinetic approach, by techniques capable of giving a direct measurement of the velocity of sorption. Kinetic measurements can be effected either by measuring the fall of pressure with time in a sealed container of known volume, or by estimating the gas flow through a capillary of known conductance. The latter method can be applied by keeping the manifold pressure constant and allowing the getter pressure to vary with time, but far more useful results can be obtained when the pressure on the getter is kept constant. Measurements at constant p_m are by us usually confined to preliminary large scale investigations. For such measurements suitable apparatus and automatic pressure recording are used, which enable us to carry out more than one test at the same time. For sorption studies at very low pressures, the normal apparatus is attached to an ultra high vacuum system. The experimental results obtained by measuring the gas flow at constant p_g, when suitably

interpreted, allow us to study the complex sorption mechanism, showing the existence of diffusion phenomena, giving useful indications about the mobility of molecules on the surface and within the film, and permitting the evaluation of the activation energy of different processes. Suitable apparatus enables us to study the influence of hot filaments and ionizing electron currents in the vicinity of the getter. A knowledge of these effects is in fact necessary for a correct evaluation of the data obtained for sorption velocities by using ionization gauges and permits these effects to be kept at a minimum in the experimental procedure. Further suitable apparatus is employed to study other parameters which may effect the activity of barium getters, such as the time of flashing, the pressure immediately preceeding the firing of the getter, the distance and temperature of the surface on which the film is formed. In particular such devices permit the study, by electron microscopy, of the structure of the barium films obtained under various conditions. Finally, the recent introduction of mass spectrometers of reduced dimensions and able to measure very low partial pressures (e.g. the omegatron), enables us to confirm the eventual chemical processes occurring on the barium film (catalytic reactions) and also it opens a way to the study of getter action on gaseous mixtures.

P. DELLA PORTA. Vedi pag. 322.

P. DELLA PORTA and E. ARGANO (*Milan*). – **Nitrogen Sorption by Barium Films.**

In previous communications nitrogen sorption on barium films having a mean thickness of 0.02 mg/cm², has been reported. This thickness had in fact been adopted to facilitate the reproducibility of results. The study of the sorption kinetics by the capillary method under Knudsen flow conditions and at constant pressure on the getter, has enabled the identification of an initial adsorption on the getter surface directly exposed to the gas, and of subsequent diffusion processes within the film, which are characterized by two different activation energies, below and above 413 °K. The present work tends to prove the applicability of such a model in the case of film thicknesses encountered in the manufacture of electron tubes (about 0.2 mg/cm²). Still looking at the problem from the tube manufactures point of view, the influence of the time of flashing of the getter on the sorption velocity for nitrogen is examined. The time of flashing is varied, in this series of experiments, from 4 to 40 seconds. The influence of the residual pressure previous to the flashing of the getter is also examined in the pressure range from 10^{-6} to 10^{-3} mm Hg. Finally, as further extension and proof of the applicability of the mechanism proposed, very thin films are employed, up to about 0.001 mg/cm². The data obtained on such films show a sorption capacity which is greatly superior to that expected from the formation of barium nitride. This result, bearing in mind the high specific value of the surface area of these films, seems to indicate an appreciable adsorption by the product of reaction itself. Finally it should be noted that examining the data obtained for the sorption of nitrogen on films of different thickness, as well as from the comparison of such data with similar results for carbon monoxide and hydrogen previously reported, it would appear that parallel mechanisms may be applied to the sorption of a number of gases by barium films.

P. DELLA PORTA and S. ORIGLIO (*Milan*). – **Hydrogen Sorption by Barium Films.**

The capillary method, under Knudsen flow conditions and at constant pressure on the sorbent, is in this work applied to the study of hydrogen sorption on evaporated barium films. Particular precautions have been taken to reduce to a minimum the influence of the hot filament and electron current of the ionization gauge (Alpert type) on the measurement of the sorption velocity. To this end, thoriated tungsten filaments have been employed and very low ionizing electron currents (0.01 mA) have been used. The experimental results have been obtained in the temperature range between 195 and 473 °K, on barium films of approximately 2 mg, evaporated from a stabilized barium-aluminium alloy and having an apparent surface area of 100 cm². A preliminary investigation of the curves obtained, which give velocity of sorption as a function of time, shows that the shape of such curves is dependent on the pressure range in which they are obtained. At the higher pressures the kinetic adsorption follows very closely the diffusion laws, as is shown by the nearly linear relation existing between quantity sorbed and square root of time. On the other hand at lower pressures, the graphs show an almost horizontal portion, corresponding to a constant velocity of sorption lasting a considerable period of time. These differences in behaviour show that for hydrogen, as for other gases, the sorption by barium films is made up of a number of phenomena superimposed on each other. The different appearance of the various phenomena for different gases can, with all probabilities, be attributed to the different coefficients of diffusion of the gases and the relative activation energies.

P. DELLA PORTA, S. ORIGLIO and E. ARGANO (*Milan*). – **The Influence of Ionizing Electron Currents and Hot Filaments on the Gas Adsorption by Barium Films.**

In studying the effect of ionizing electron currents on the sorption of gases by getters, it is necessary to distinguish between: *a*) the action of the ionizing electron current and the action of the hot filament employed; *b*) the pumping action of the hot filament and of the ionizing current, and the sorption by the getter; *c*) the gettering of activated particles and usual gettering of gaseous molecules. Bloomer has pointed out how the activating action of the ionizing electron current is to be added to the normal gettering by barium films. This criterion has been applied in all our work on the various phenomena mentioned previously: normal gettering, electrical clean-up, pumping effect of the hot filament and gettering of activated particles. By using an analogous additive principle, it is still possible to employ an ionization gauge of the Alpert type to measure the pressure, even when studying the effects of an ionizing electron current, by falling back on supplementary electrodes and tubes for the study of other parameters. The measurements have been carried out employing the capillary technique at constant pressure on the getter. The apparatus used in this experiment is obtained by simple modifications of devices already described in previous communications. Such modifications introduce, on the getter side of the capillary, supplementary tubes with the required electrodes. With such devices we have carried out a number of tests to compare the velocity of pumping with and without getters, in various gases, when altering temperature and size of the surfaces and the intensity and energy of the

ionizing electron beam. Particularly striking results have been obtained when employing ionization gauges of special construction, characterized by the use of an extra grid in one case, and of filaments of different properties, within the same tube, in another. In the case of nitrogen, the pumping effect of the hot filament (in the absence of ionizing electron current) becomes noticeable only at very high temperatures (about 2800 °K). This pumping effect does not change the velocity of sorption of the getter, only producing the additive effect previously mentioned. On the other hand, the electron current produces an increase in the gettering velocity of barium films which is proportional to the ionization produced. For hydrogen we have, as is already well known, a relatively large increase in the pumping action of the hot filament. However this occurs at a much lower temperature. This increase is once again independent of the presence of the barium film, but is partially dependent on the temperature of the surface. The increase produced by the ionizing electron current is practically independent of the evaporated barium film, as opposed to what is found for nitrogen. In the case of carbon monoxide, for which the effects of the hot filament only become apparent at temperatures above 2600 °K, a very small influence of the electron current is noticeable in the presence of the getter, but it is almost negligible when the getter is not present. Preliminary trials for oxygen and carbon dioxide seem to indicate a behaviour similar to that of carbon monoxide.

H. W. Ehlbeck. Vedi pag. 323.

W. Ermrich. Vedi pag. 317.

F. Flecken. Vedi pag. 321.

J. C. Francken and J. van der Waal (*Eindhoven*). – **Residual Gases in Picture Tubes.**

The omegatron, a small mass spectrometer, has been used to analyse the residual gas in television picture tubes. First the principle of operation of the omegatron is briefly recalled, and a short description of the Philips execution is given. This instrument is mounted in a side arm connected to the bulb of a television tube, together with an ionization gauge and the whole assembly is pumped simultaneously. Both completed tubes and partly processed bulbs have been prepared in this way. The residual gas after seal-off has been analysed at different stages of processing, *i.e.* before and after flashing the getter, after drawing current with the ionization gauge and during shelf-life. The gas-content after seal-off mainly consists of hydrogen, nitrogen and methane. Generally in the bulb blanks hydrogen is the main gas whereas in completed tubes nitrogen has the higher pressure. In all cases small traces of H_2O, CO and CO_2 have been found. All these gases disappear nearly completely after the getter has been flashed, but this operation produces an appreciable amount of hydrocarbons and some argon. Drawing current with the ionization gauge or with the electron gun of a completed tube results in a break-down and a subsequent adsorption of the hydro-carbons. On shelf-life these gases are partly desorbed. Scanning the screens results in a very rapid decrease in pressure of the hydro-carbons.

J. J. B. Fransen and H. J. R. Perdijk (*Eindhoven*). – **Absorption of Gases by Barium Getter Films Applied as a Tool.**

Gas absorption measurements by barium getter films can be performed with the aim to gather information on what happens with the *gas* during the absorption. On the other hand the gas absorption of various gases can also be used to obtain information on the *structure* of the getter film itself. So from hydrogen — or oxygen — capacity measurements at room temperature can be learnt whether the getter mirror has been contaminated during the flashing process or not. CO-absorption capacity measurements at ambient temperature make possible a comparison of the microscopic area of getter films made by means of various types of alloy getters. The « melting curve » used to investigate the reliability of the barium source will be discussed. Some experiments on the absorption capacity of CO, in dependence of the flashing conditions, will be dealt with.

J. P. Freytag (*Levallois-Perret*). – **Emploi d'une diode d'essai comme moyen de contrôle des matériaux de construction des tubes électroniques.**

Des expériences acquises dans la pratique des tubes hyperfréquences à grande puissance (domaine des multi-mégawatts) ont montré que les matériaux constituant le tube sont aussi importants que ceux constituant la cathode thermoélectronique elle-même. En effet, dans le cas de la cathode à oxydes, il a été reconnu depuis l'époque de Wehnelt que le gaz résiduel a une influence sur le comportement des cathodes. On a reconnu depuis longtemps aussi, l'influence du gaz dégagé par les électrodes et par l'enveloppe lors du fonctionnement du tube, sur l'émission. C'est l'ensemble de ces phénomèmes qu'on a appelé « phénomènes d'ambiance », le terme « ambiance » désignant les gaz ou vapeurs au voisinage de la cathode, et dans un sens plus large, les sources de ces gaz et vapeurs que constituent les pièces de construction du tube. Etant donné qu'il n'est pas toujours commode dans la pratique des tubes d'élucider la nature des gaz ambiants en fonction des matériaux et de leurs traitements; il s'est avéré utile d'examiner l'influence des matériaux sur une cathode à oxydes dans une diode de contrôle, une technique en principe connue, pour contrôler les matériaux des tubes récepteurs («diodes standard »). La diode en question est adaptée aux besoins des tubes à régime pulsé et permet — grâce à ce fait et contrairement aux diodes standard habituelles — de mesurer les performances de cathodes sous des conditions de régime à l'exception de la tension analogue qui est réduite. Après description rapide de cette diode, on montre que l'influence de l'ambiance se révèle par trois allures différentes, le courant maximum utilisable (limité par la charge d'espace) étant imposé, ou par l'apparition du phénomène de « sparking » ou par la saturation. On montre l'influence des conditions du régime (continu ou pulsé, durée d'impulsion et fréquence de répétition) sur le courant pour lequel se produit le sparking et l'on indique les résultats obtenus avec certains matériaux d'anode tels que Fer, Kovar, Titane, Molybdène, Cuivre, Platine et Nickel. Se sont révélés comme les meilleurs matériaux d'anode le Platine et le Nickel; dans ce dernier cas, on a pu mesurer, en régime pulsé, une densité de courant dépassant 160 A/cm^2, la limite n'étant pas imposée par la saturation, mais par le sparking. Finalement, on montre l'influence de la nature du verre utilisé comme enveloppe de la diode. En conclusion, la diode se révèle comme un moyen de

contrôle relativement simple. Néanmoins, lorsque l'on veut mettre en évidence la nature des gaz ou vapeurs ambiants, elle ne dispense pas de mettre en jeu des moyens plus perfectionnés tels que le spectromètre de masse, sujet de l'exposé de R. J. VARNECKE.

S. FUKAGAWA (*Tokyo*). – **Gettering Activity of Zr, Ti and Ba for Oxygen Gas under Mercury Vapour.**

The absorbability of oxygen gas in barium, titanium and zirconium is well known, but when mercury vapor is simultaneously present this influences seriously the absorbability of oxygen gas in Mercury Vapor Hot Cathode Tubes containing mercury vapor. An easy method for the measurement of getter activity in oxygen gas under mercury vapor is to measure the electrical conductivity of the oxide layer of the oxide cathode. That is, the oxide cathode itself is a semiconductor of excess Ba metal type, and the comparison relation with the pressure of its exterior oxygen (in this case, oxygen inside the tube) has been utilized. For this purpose, an oxide part has been coated over the pure nickel sleeve, and over this a pure nickel wire is wound as a probe. The electrical conductivity of these two poles is measured at a regulated temperature. The mixed oxygen and mercury vapor inside the tube, is measured by the increase-decrease of oxygen. By this method, the absorbability of oxygen has no change in titanium and zirconium even in presence of mercury vapor, but in regard to barium in presence of mercury vapor, this latter amalgamates with mercury vapor and thus the previously absorbed oxygen is freed.

H. FUKUSHIMA. Vedi pag. 313.

S. GARBE, A. KLOPFER and W. SCHMIDT (*Aachen*). – **Some Reactions of Water in Electron Tubes.**

On pumping tubes a great part of the gases present is formed by H_2O vapour, which desorbes from the surfaces and is also evolved from various materials, specially glass and mica. The water in sealed-off systems undergoes various reactions. Water is present in glasses as OH-groups in different states of binding. For short outgassing time the evolution of water from the surface prevails, resulting in a decrease of the surface coverage with water. The concentration of the chemically bound water near the surface can be lowered by pre-degassing or chemical attack. On cooling down, the H_2O partial pressure in sealed-off glass systems decreases, because the adsorption equilibrium changes. Below 10^{-5} Torr the adsorption of water on glass is composed of the physical adsorption and the chemisorption, the latter being accompanied by a desorption of hydrogen. Reactions with hot cathodes lead to the formation of H_2, CO_2, CO and CH_4. Cold oxide cathodes take up water, which again is given off on heating. On reaction with the barium-getter besides H_2, which again is taken up by the unsaturated getter, also hydrocarbons, especially CH_4, are formed. The rate of CH_4-formation is approximately proportional to the H_2O pressure. In a T.V. picture tube after flashing the getter an amount of water of $8 \cdot 10^{-3}$ Torr l had been let in, resulting in a far higher level of H_2, CH_4 and CO_2 than in normally processed tubes even after 180 hours of life and operation. The H_2O pressure, however, had decreased from above

$1 \cdot 10^{-5}$ Torr to $4 \cdot 10^{-9}$ Torr. Generally we may conclude, that an increased water evolution in tubes essentially leads to a higher residual pressure of the above mentioned gases during life.

S. Garbe. Vedi pag. 318.

M. D. Gibbons and V. L. Stout (*Schenectady, N. Y.*). – **Gettering Properties of Alloys of Zirconium and Titanium.**

In previous gas sorption studies with titanium, is was observed that this metal was capable of sorbing hydrogen at room temperature [1]. However, it was also observed that even a slight oxide film on the surface of titanium would inhibit further sorption of hydrogen. Oxide films on titanium are fairly stable below 450 °C. At this temperature and above they diffuse into the bulk of the metal. However, at 450 °C and above, the metal is incapable of holding much hydrogen. Thus, in order to continuously sorb water vapor with a getter like titanium, it is necessary that the metal sorbs oxygen at low temperature. Some experimental results describing the oxidation and dissolving of oxide films for various crystal orientations will be presented. This paper will describe experimental results with Zr-Ti alloys for various gases. Data were taken by trapping a quantity of gas in the presence of the getter; and measuring the pressure as a function of time for various temperatures. The data for oxygen, air, nitrogen and carbon dioxide seem to follow a parabolic law, that is, a plot of pressure vs. square root of time yields a straight line. In the case of oxygen, there were considerable differences between the alloys. For example, the parabolic rate constant for the best alloy, 87.5 atomic percent Zr-12.5 atomic percent Ti was a thousand times that of Ti. This alloy sorbed oxygen at 180 °C as well as Ti sorbed oxygen at 500 °C. The data for air sorption showed that it is gettered best by alloys with nearly equal molar compositions. The differences in the parabolic rate constant for the alloys in the air case were less than a factor of ten. For nitrogen and carbon dioxide, the data indicated little difference between the alloys. However, for carbon dioxide, there was considerable saturation effect at low concentrations. The ability of the better alloys to dissolve their oxide film and sorb hydrogen at low temperatures was demonstrated. It is believed that the best alloy is capable of sorbing water vapor at low temperatures.

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[1] V. L. Stout and M. D. Gibbons, *J. Appl. Phys*, **26**, 1488 (1955).

T. A. Giorgi. Vedi pag. 301.

R. Haefer (*Balzers*). – **Zur Frage der Verwendbarkeit von Metall-Öldiffusionspumpen beim Arbeiten mit auf Kohlenwasserstoffe empfindlichen Entladungsröhren.**

Im stationären Zustand ist der Enddruck im Rezipienten über einer Metall-Öldiffusionspumpe mit Metalldichtungen bekanntlich durch die Summe aus Sättigungsdampfdruck des Öls und Partialdrücken der Zersetzungsprodukte gegeben (einige 10^{-8} Torr bei Raumtemperatur). Beim Arbeiten mit auf Kohlenwasserstoffe empfindlichen Röhren

ist es aber oft wünschenswert, bedeutend niedrigere Drücke zu erreichen. Dies ist auch ohne Benutzung von Tiefkühl- oder Alpertfallen möglich durch Arbeiten im nichtstationären Zustand, d.h. unmittelbar nach dem Ausheizen der Röhre. Für die Dauer des nichtstationären Zustandes ist die Zeit zur Ausbildung einer monoatomaren Bedeckung in der Röhre ein Maß. Diese Zeit läßt sich mit Hilfe des Feldelektronenmikroskops bestimmen. Für eine Reihe von Anordnungen werden experimentelle Daten mitgeteilt. Der nichtstationär erreichbare Druck ist durch eine Reihe von Faktoren gegeben (Art der Pumpe, Treibmittel, Vorpumpe, Baffle), über deren Einflüsse ebenfalls experimentelle Angaben gemacht werden. Die für die technische Anwendung sich ergebenden Folgerungen werden diskutiert.

A. Harte. Vedi pag. 315.

K. Hashimoto, H. Iwayanagi and H. Fukushima (*Mobara City*). – **Measurement of Gas Evolution and Absorption from Materials Used in Vacuum Tubes.**

As a first step of their study on the gas evolution from materials used in vacuum tubes, the writers took up three methods of measuring in common use, namely, the gas accumulation, the gas flow (differential Pirani gauge) method, and the flowmeter method. The writers, while reviewing the principles of these methods, discussed their sensitivities in relation to various gases, and mentioned difficulties in experimenting with low pressure gases, especially the outgas from the glass wall and other parts of the vacuum system as well as the reaction between the sample material and the gases evolved from it. On the basis of the experimental results, the writers have developed the gas evolution and absorption gauge in the gas flow method, which record the measurement automatically. Some examples of the actual measurement of outgas characteristics of metal plates are given in this report. The characteristics of the gas absorption of titanium has many interesting problems and it suggests useful applications in the field of the vacuum tube production. The writers also carried out experiments for studying the gas absorption rate of titanium for such gases as nitrogen, oxygen, carbon mono- and dioxide, at various temperatures. The pressure of the gas sealed in a vessel and contacted with the titanium surface decreased exponentially with time in the pressure range of this experiment, from which is concluded that the absorption speed is nearly constant. From this dependence the activation energies of absorption for these gases were calculated. Moreover, some interesting phenomena such as the hysteresis effect of gas absorption and the jump of speed which occurred abruptly in the process of carbon dioxide absorption, were found.

K. Hashimoto and K. Kitagawa (*Mobara City*). – **Some Barium Getter Problems on the Vacuum Tubes.**

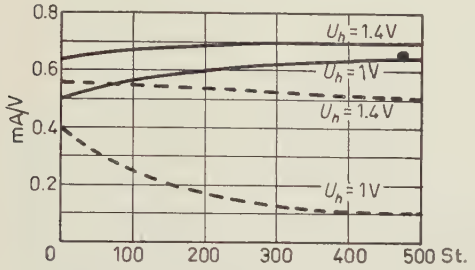
The writers have carried out experiments on the action and behaviour of getters as used in the actual production of, for example, receiving tubes, power tubes, cathode ray tubes, mercury rectifiers and X-ray tubes. Initially the results obtained from the study of the flashing conditions of the getter and the effect of these conditions on the

sorption of gases are presented. Results are given for the quantity of gas sorbed during the first minute, the following four minutes and the successive ten minutes, for getters which have been evaporated for 10 and 60 seconds. The difference in the quantity of gas initially sorbed when using different times of flashing are quite remarkable in the case of N_2 and H_2. Due to this the quantity of gas sorbed can nearly be doubled by a rapid firing of the getter. This difference is less marked for O_2 and negligibly small for CO and CO_2. Similar studies have been made using rare gases, these studies have been helped by using the electron microscope to study the surface of the getter film. Studies have also been made on the influence of the distance between getter and condensing wall and hence of a larger area of barium film. By examining cathode ray tubes, the dependence of the tubes pressure and life on the conditions of flashing of the getter have been studied. For non aluminized picture tubes data are presented giving the most favourable angle of connection of the getter assembly to the electron gun. The modifications made to the cathode structure of X-ray tubes in order to obtain the most favourable conditions when using the getter are reported. Data on the pressure obtained under such circumstances are also presented. Subsequently a study is given of the gas sorption by barium, magnesium and titanium, in mercury vapour tubes. Finally there is a study of the influence of the getter on the emission from the oxide cathodes employed in mercury rectifiers made with an apposite apparatus.

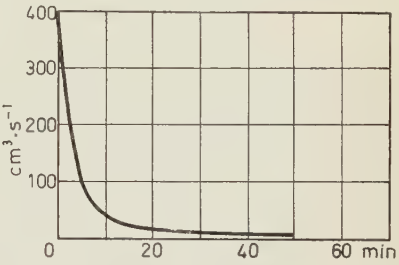
J. Hejzlar (*Vuvet*). – **Das selektive Getter.**

Bei der Lösung von Stabilitätsproblemen der direkt geheizten Oxydkathodenröhren mit Wolframdraht haben wir festgestellt, daß für die Konstanthaltung eines hohen Sättigungsstromes während des Betriebes ein niedriger Wasserstoffdruck von der Höhe ($10^{-5} \div 10^{-7}$) Torr in der Röhre notwendig ist. Die günstige Wirkung des Wasserstoffes auf die Aktivität einer solchen Kathode ist im Diagramm, in welchem der Zeitverlauf der Steilheit für die Röhren 1R 5T mit Ba und mit einem «selektiven» Getter dargestellt ist, klar zu sehen. (Aufgetragen sind die Mittelwerte von 10 Röhren mit beiden Arten des Getters.) Die Bedingungen der Lebensdauerprüfung waren praktisch dieselben, wie in einer Oscillator-Mischstufenschaltung. Es hat sich gezeigt, daß der Wasserstoff sowie die Zwischenschicht als auch die eigene Oxydschicht aktiviert. Weiter haben wir den Einfluß des Wasserstoffes in dem Druckintervall von 10^{-5} bis 10^{-7} Torr auf die Oxydkathode mit Nickelunterlage, vor allem während der Lebensdauer studiert und in allen Fällen günstige Ergebnisse erhalten. Aus diesen Gründen haben wir ein solches Getter, das einen andauernden Wasserstoffdruck in oben angeführten Grenzen zu erhalten vermag, realisiert. Gleichzeitig muß dieses Getter genug große Pumpgeschwindigkeit für die übrigen Restgase bei niedriger Temperatur aufweisen und auch die Kosten dürfen nicht hoch sein. Zur Herstellung dieses Getters haben wir die seltenen Erden und zwar Cermischmetall gewählt. Cermischmetall wird zuerst im Vakuum geschmolzen um Oxyde wegzuschaffen. Weiter wird Cermischmetall im Vakuum mit Kupfer und Aluminium, also mit Metallen, die sehr kleine Gaslöslichkeit aufweisen, legiert um ihn zu stabilisieren. Durch die Legierung von Eisen wird eine grobe kristallinische Struktur erreicht, sodaß der Ingot leichter zerkleinert werden kann. Die oben angeführte Legierung in Pulverform wird mit Titanhydridpulver gemischt und daraus Tabletten gepreßt. Durch das Erwärmen der Gettertablette auf 750 °C wird Wasserstoff aus Titanhydrid gelöst und von der Legierung in gewissem Maße ab-

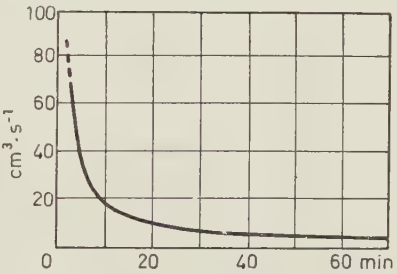
sorbiert. Auf diesem Wege wird das Getter aktiviert durch die Zerstörung des Kristallgitters der Legierung. Die Aktivierung des Getters verläuft während des Pumpprozesses der Röhre. In den Diagrammen sind die Pumpgeschwindigkeiten für CO_2 und Luft von einer Tablette von 5 mm Durchmesser (Gewicht 50 mg) bei 65 °C angeführt.



Der Zeiverlauf der Steilheit der Röhre 1R5T. ——— das selektive Getter, - - - - Ba Getter Die Steilheit gemessen bei $U_h = 1{,}4$ und 1V.



Die Pumpgeschwindigkeit des selektiven Getters für CO_2. Tablette 5 mm Durchmesser, 50 mg Gewicht.



Die Pumpgeschwindigkeit des selektiven Getters für die Luft.

Mit diesem Getter wurden in der Röhrenfertigung Empfängerröhren EF80, PCF82, PY83, PL81, PL83, ECH81, EBF89 u.a. hergestellt. In allen Fällen erhalten wir gute Erfolge. Die Stabilität der wichtigsten Parameter während der Lebensdauer, namentlich die Steilheit, Kontaktpotenzialdifferenzen, der äquivalente Rauschwiderstand der Kathode, der Sättigungsstrom, war besser als diejenige der Röhren mit Ba-Getter.

L. Holland and A. Harte – **The Pumping Performance of Titanium Getter-Ion Pumps of Small Throughput.**

The gas sorption characteristics of evaporated titanium deposits and of a small Penning pump with titanium electrodes have been studied and compared. The Penning pump also served as an ion-source for activating the gas being sorbed by the titanium deposit. The sorption apparatus consisted of a bakeable stainless steel getter chamber of 1400 cm^2 area and a metal Penning pump of 75 mm diam. The vacuum seals were made with metal gaskets and the pressure measured with an ion-gauge. The gas to be sorbed was admitted to the getter chamber from a reservoir via a calibrated leak. Sorption rates were measured in the pressure interval $(10^{-6} \div 10^{-3})$ mm Hg. The pumping

speed of an evaporated Ti-film was negligible (< 0.1 l/s) for non-activated gases, but greatly enhanced when the Penning ion-source was in operation as previously found by Gale. Inert gases were only sorbed by the Penning pump. Speeds measured for the Penning pump alone and for a fresh Ti-film with the ion-source in operation were as follows:

Gas	Air	N_2	O_2	H_2	A
Penning Pump (1)	5	7	6.3	44.5	1
Ti-film + ioniz. (2)	56	56	56	234	1

The enhanced speed of the Ti-film in the presence of ionized gas could not be attributed to the ions flowing to the getter surface because the getter chamber was at a positive potential. The exceptionally high speed obtained for hydrogen when ionized could have been due to the formation of atomic hydrogen which readily diffused into the titanium deposit. It is difficult to attribute the enhanced speed of oxygen to molecular dissociation because the rate of sorption would be dependent on diffusion within a dense metal oxide layer. Hydrocarbon and inert gases were present in the oxygen and nitrogen used and these could have reduced the sorption rate of the film. Thus the inert gas impurity would only be exhausted by the ion-source. The hydrocarbon impurities could have been adsorbed to the surface of the getter film reducing the diffusion of the principal gas into the deposit. Operation of the ion-source would also lower the concentration of hydrocarbons in the gas to be sorbed. Sorption rates have been measured for gas mixtures of argon and pure hydrogen, and nitrogen and butane. The sorption rates obtained are in approximate agreement with the hypothesis. Measurements are rendered difficult when using hydrocarbon-gas mixtures due to the uncertainty in determining the sensitivity factor to be used with the ion-gauge. The results however are of practical value when determining the usefulness of Ti-films and Penning pumps for exhausting sealed electronic devices.

(1) Within pressure range ($10^{-6} \div 10^{-3}$) mm Hg.
(2) Measured at 10^{-6} mm Hg.

H. Iwayanagi. Vedi pag. 313.

S. Jerič and E. Kansky (*Ljubljana*). – **A Method for Measuring of Caesium Vapour Pressure in Photoelectric Tubes.**

A simple method for the determination of caesium vapour pressure (P_{Cs}) in the 10^{-4} to 10^{-15} mm Hg range based on the surface ionization of caesium on hot tungsten has been described and its theory and accuracy have been discussed. The continuous ion current method allows the determination of P_{Cs} in the ($10^{-4} \div 10^{-9}$) mm Hg range whilst the discontinuous flashing method extends this range from 10^{-9} down to 10^{-15} mm Hg. The latter method enables the determination of very low residual P_{Cs} in photoelectric tubes. Construction details of various photocells and 11-stage photomultipliers with built-in ionization diodes and electrical circuits used are given. Usefulness of the method is illustrated by following the process of caesium bonding by antimony and silver oxyde surfaces and of the adsorption of caesium on glass.

S. Jerič. Vedi pag. 317.

E. Kansky. Vedi pag. 316.

E. Kansky and S. Jerič (*Ljubljana*). – **Some Results of the Measurement of Caesium Vapour Pressure in Photoelectric Tubes during their Manufacture and Life.**

Residual caesium pressure (P_{Cs}) in phototubes with Ag-O-Cs and Cs_3Sb cathodes has been determined by using the method described in the previous paper and compared to the calculated values. P_{Cs} in a Cs_3Sb cell at room temperature is about 10^{-14} mm Hg, and in a Ag-O-Cs cell about hundred times lower. We observed an appreciable increasing of P_{Cs} in Cs_3Sb photocells during the operation. « Current activation » of Cs_3Sb photocathodes can be explained by this effect. P_{Cs} data for different photocathode activation processes of photocells and photomultipliers are given. Sensibilization of photocathodes with minute quantities of oxygen lowers the P_{Cs}. Relations between P_{Cs} and photomultiplier dark current are discussed.

K. Kitagawa. Vedi pag. 313.

A. Klopfer and W. Ermrich (*Aachen*). – **Properties of a Small Titanium-Ion Pump.**

For many evacuation processes it is of advantage to have a small portable pump which maintains a low pressure for a long period of time and which can work without supervision. Here we describe such a small pump. The getter material may be evaporated continuously or in steps and a Penning discharge is maintained in the vaporization chamber. The electrode assembly is in principle the same as that of a simple Penning gauge, but the cathodes consist of twisted tungsten and titanium wires. To operate the pump a d.c. voltage of 2 kV is applied between its anode and its cathodes. The latter are heated by passing an a.c. through them. The maximum power consumption of the pump is 100 W, at low pressures this value is reduced to about 20 W. The cylindrical pump housing has a diameter of 34 mm and a length of 60 mm. The pump weighs 40 g alone and 450 g with the permanent magnet. Therefore it is easy to transport the unit. The pumping speed for a chemically active gas depends on the evaporation rate of the getter material and on the gas influx. A constant pumping speed, independent on the gas influx, can be obtained, if the evaporation rate is varied proportional to the pressure on the pump. The maximum obtainable pumping speed is about 50 l/sec for CO. The discharge current is only a measure of the gas pressure, if the cathodes are cold. With cathodes hot, the discharge current gives the value for the steady evaporation rate. The total quantity of chemically active gases that can be removed, is dependent on the amount of getter, the cathodes are loaded with. Usually the pump contains 50 mg Ti and therefore the quantity of gas removed under optimum conditions is 2.5 Torr l in the case of CO. The initial operating pressure is about 10^{-4} Torr. The residual gases during evacuation of simple

vacuum systems with the pump described were analysed by means of an omegatron. The factors determining the final pressure in vacuum systems at various states of degassing are discussed. The lowest pressure obtained with the pump was below the X-ray limit of the ion gauge ($< 2 \cdot 10^{-10}$ Torr).

A. Klopfer. Vedi pag. 311.

A. Klopfer, S. Garbe and W. Schmidt (*Aachen*). – **Residual Gases in Vacuum Systems.**

A general survey will be given of the residual gases, which are most frequently found in sealed-off high and ultrahigh vacuum systems. In principle the following gases evolve from common materials: H_2, N_2, H_2O, CO and CO_2, but their amount depends on the materials used as well as on the previous treatments and on impurities. The composition of the residual gases in the considered vacuum systems is determined by the interactions between the gases evolved and the surfaces. Such interactions are: adsorption, chemical and exchange reactions. Some of these interactions have a dominant influence on the kind of gases which are present. H_2O and CO_2 are strongly adsorbed on the cold surfaces. The reactions of H_2 and H_2O with the carbon impurities or the carbide-like constituents of getter materials lead to the formation of hydrocarbons. At the reactions of gases with hot cathodes, the temperature and the impurities of the cathodes influence the final products much more than the kind of cathodes. The clean-up by ion pumping must also be considered. Due to these above mentioned reactions the residual gases can be classified according to the conditions prevailing in vacuum systems.

RESIDUAL GAS SCHEDULE

Temperature of the cathode	without getter	with getter	with getter and ion pump
20 °C	H_2, N_2, CO, CH_4	CH_4, C_2H_6, C_3H_8	H_2, N_2, CH_4
900-1200 °C	H_2, N_2, CH_4, CO	H_2, CH_4, N_2 (A), CO	H_2, N_2, CH_4 (A), CO
1500-2000 °C	CO, N_2	CH_4, CO, N_2 (A)	CH_4, CO, N_2 (A)

The results were checked and confirmed by a large number of gas analyses by means of an omegatron. An example is the case of the gases in electron tubes. After seal-off these tubes traverse the schedule from left to right.

H. Kobayashi. Vedi pag. 326.

R. W. Lawson (*London*). – **The Influence of Residual Gas on the Performance of the British Post Office 6P12 Submarine Telephony Repeater Valve.**

The valve developed by the British Post Office in 1949 for use in its submarine telephony schemes, the type 6P12, resembles an ordinary pentode receiving valve in many respects. The most important difference is the replacement of the active nickel core (which gives rise to valve failure due to interface growth) by one of pure platinum. The most important parameter, by which the suitability of pentode valves for use in submarine telephony schemes is judged, is the stability of mutual conductance. This in turn depends on the stability of the cathode activity. As an oxide cathode adsorbs gas, its activity declines and this is reflected in a fall in the mutual conductance. The problem of producing a satisfactory passive core valve is basically one of ensuring that the oxide cathode operates in an essentially gas-free environment. Pumping the valves on high grade bench pumps capable of an ultimate vacuum of $2 \cdot 10^{-7}$ Torr coupled with the use of barium flash getter is not sufficient to ensure the production of passive core valves with satisfactory life characteristics. The major source of gas giving rise to the poor life characteristics is found to be the occluded gas in the various valve components. This gas is released when the components are raised to elevated temperatures during the pumping and ageing of the valve and can also be evolved during the life of the valve. The virtual elimination of this gas from certain of the valve components prior to valve assembly is one of the chief factors that has permitted the development of valves suitable for use in submerged repeaters. The elimination of the gas in the components is discussed with particular reference to those components fabricated from nickel wire and sheet. The effects on valve performance at zero time and during life of rendering the components gas free are discussed. It is concluded that the improved life characteristics obtained on valves made with gas-free components is due to two causes. Firstly the total amount of gas released during the pumping and ageing of the valve is reduced and this results in a reduction of the initial pressure, p_0, defined as the pressure in the valve at the commencement of life test. Secondly, using gas-free components ensures a very low rate of gas evolution during life. The stability of both cathode activity and mutual conductance is achieved in passive core valves having gas-free components in a few hundred hours and this coincides with the time taken for the initial gas pressure, p_0, which has a value of about $1 \cdot 10^{-7}$ Torr to be reduced to a stable value in the region $1 \cdot 10^{-9}$ Torr. It is concluded that the whole or part of the initial gas pressure is adsorbed by the cathode which loses some of its activity in the process. In the absence of gas generators in the valve, ensured by the degassing of the components prior to valve assembly, the cathode activity and mutual conductance remain stable.

L. Malter and H. Mandoli (*Palo Alto, Cal.*). – **Electron Tube Processing with Getter-Ion Pumps.**

A description of the VacIon getter-ion pump and of its physical processes is presented. Its performance and advantages over older pumping techniques are discussed. Particular attention is paid to the processing of electron tubes with VacIon pumps. Actual experience with thousands of tubes is presented, pointing out the very considerable benefits as regards performance and economic savings achieved by employing

this technique. Brief mention is made of two other matters: 1. The use of sorption pumps to go from atmospheric pressure to the starting region of VacIon pumps. This completely eliminates the possibility of introducing contaminants into a system during processing. 2. The use of VacIon pumps as appendages of electron tubes so as to maintain the vacuum against the consequences of 1) inadequate processing, 2) outgassing during operation and, 3) leaks.

H. Mandoli. Vedi pag. 319.

R. P. Misra (*Bloomfield, N. J.*) – **Use of the A.S.T.M. Reference Planar Diode for Studying Getter Properties.**

A short description of the A.S.T.M. Reference Planar Diode will be presented even though detailed description is available in *Le Vide* Number 77, September-October, 1958. Particular points of importance about this diode which make it suitable for using it to study life properties of the cathode when different getters are used will be discussed. Some data will be presented indicating the gases inside tubes as measured by a special mass spectrograph tube and procedures pointed out whereby quantitative use of this tube may be made to study the effect on cathode life. Curves indicating the use of the tube itself as an ion gauge for residual gas pressure will be presented. Finally the availability of the parts for this reference diode to laboratories in Europe will be pointed out and mechanisms sought whereby communication on data between European investigators and the A.S.T.M. Group in the United States may be facilitated.

A. Nasini, F. Ricca and G. Saini (*Torino*). – **Clean Surfaces and Sorption of Gases.**

Chemisorption studies have progressively shown the importance of having available truly clean surfaces to obtain valuable results. To this end in the past few years extensive use has been made of evaporated films: however, recent trends seem to prefer the use of bulk materials (filaments, foils, tips) which can be degassed at high temperature. Such materials are much more versatile than films, and give a useful basis to the development of new techniques for the study of surface phenomena. These surfaces can be used any number of times; they further permit the elimination of secondary phenomena, not strictly related to the surface, such as diffusion within the discontinuous structure of evaporated films. Techniques employing bulk materials are necessarily restricted to those metals which do not possess an appreciable vapour pressure at the degassing temperatures required. However, the results which have recently been obtained with this type of sorbent, by field emission microscopy, field ion microscopy and flash filament technique, are of great theoretical interest and can be applied to most of the other metals. We limit ourselves to quote the information obtained about the existence of: *a*) various types of atoms on the metal surface, characterized by different sorption properties; *b*) different coefficients of surface diffusion for the different crystal faces; *c*) different states of the gas adsorbed on the metal. Concerning this latter point, useful information can be obtained from infrared spectro-

scopy of the adsorbed molecules. This complex picture of the observed phenomena is confirmed by our results for the adsorption of nitrogen and carbon monoxide on tungsten. The technique used to measure the velocity of adsorption, based on the flow of gas through a capillary of known conductance, is similar to that used in the field of getters; the adsorbent is a tungsten lamina of 0.0025 cm thickness and of surface about 30 cm^2; the measurements have been carried out in the pressure range of 10^{-7} to 10^{-8} mm Hg, and in the temperature interval between 90 and 480 °K. A problem of particular interest arises from the immeasurably low temperature coefficients and from the fact that the velocity of adsorption is initially independent of the surface coverage. The theoretical hypotheses put forward concerning this problem are briefly examined. The correct interpretation of such complex surface phenomena seems to be necessary even for the study of gas sorption by evaporated metal films.

D. Newson. Vedi pag. 303.

S. Origlio. Vedi pag. 308.

H. J. R. Perdijk (*Eindhoven*). – **Structure of Barium Getter Films.**

The structure of barium films, originating from barium alloy getters, depends on a variety of factors. Some of them are parameters given by the manufacturer. As, for instance, the quality of the barium alloy used, the additions applied, the getter container, its material and shape. Further there are factors, which depend on the application of the getter, such as the valve type in which it will be applied, mounting-, sealing in-, pumping-, evaporation-conditions and so on. The behaviour of a getter in the valve will depend on its sensitivity to all these factors. The « melting curve » reflects the reliability of the getter holder during the heat treatment, when evaporating the barium. The « yield curve » will give additional information on the rate of evaporation of barium. Both properties depend on the getter construction. From them the most efficient heat treatment can be derived. The absorption capacity of CO at room temperature proves to be largely independent on the area of the glass envelope covered by barium. It mainly depends on the amount of barium evaporated. A useful hypothesis is, that barium is sputtered out off the getter-holder during the high frequency heat treatment. By means of photographs made with an electron microscope the effect of various variables during flashing on the structure of the getter mirror will be demonstrated.

H. J. R. Perdijk. Vedi pag. 310.

G. Reich and F. Flecken (*Köln-Bayental*). – **Analysis of Partial Pressures by Means of Omegatron and Farvitron: comparative view of the ranges of application.**

The wide range of high vacuum technical problems, a solution of which may only be obtained by means of partial pressure analysis, is responsible for the fact that a variety of measuring methods becomes necessary. This applies in particular to sensiti-

vity, pressure range, and rapid and comprehensive response. The two partial pressure gauges — the Omegatron and the Farvitron (see paper by W. Tretner) — dealt with in the present paper are matching each other in an ideal manner. While the Omegatron having high sensitivity and good resolving power allows only the subsequent measuring of single partial pressures, the Farvitron gives a complete survey of the composition of partial pressures on an oscillograph. For this reason the Farvitron having less resolving power and lower sensitivity is highly suitable for indicating partial pressures especially during rapidly varying processes in the pressure range between 10^{-8} and 10^{-5} Torr.

R. Ricamo. Vedi pag. 302.

F. Ricca. Vedi pag. 320.

F. Ricca (*Turin*) and P. della Porta (*Milan*). – **Carbon Monoxide Sorption by Barium Films.**

A number of workers have in the past few years studied carbon monoxide sorption by barium films, often obtaining diverging results. The complex nature of the problem, which cannot be considered as a simple surface adsorption, is shown by the work of Arizumi and Kotani, who propose a model based on the existence of lattice imperfections in the barium film and also by the work of Bloomer who applies to this phenomenon the Mott-Cabrera theory for the oxidation of metals. The problem is here considered in view of the results obtained by the capillary technique at constant pressure on the getter. The experiments have been carried out in the temperature range between 195 and 473 °K. The kinetics of sorption may be studied and an analysis of the mechanism of the process may be undertaken from the obtained data. The initial velocity of the adsorption is approximately the same at the various temperatures at which the experiments were carried out, and remains nearly constant for a period of time which increases with increase in temperature. The decreasing part of the sorption velocity curve can be interpreted as due to a diffusion phenomenon. The initial part of the curve at constant velocity, which is characteristic of carbon monoxide sorption by barium, had been misinterpreted by some previous workers (Morrison and Zatterstron, Bloomer) and attributed to the limited conductance of the capillary, and so considered non relevant to an explanation of the phenomenon. In agreement with the work of the previously mentioned Japanese authors, we recognized the value of this result, which depends on the fact that various processes are involved in the phenomenon, each one kinetically relevant according to the pressure and temperature prevailing and according to the quantity of gas already sorbed by the getter. The whole phenomenon is thought to be due to an initial adsorption on the surface and to a subsequent surface diffusion having a low activation energy or, at sufficiently high temperatures, to a bulk diffusion, which is characterized by a higher activation energy. The end of the constant velocity portion of the curve is thought to be related to the instant when the diffusion becomes slower than the surface adsorption. The evaluation of the energy of activation for the diffusion phenomenon reveals the existence of a critical temperature in the neighbourhood of 80 °C.

N. W. Robinson (*Salford*). – **The Action of Molybdenum, Tungsten, Tantalum and Nickel on Residual Gases in a Vacuum System.**

The interaction between the above metals and residual gases in a vacuum system is studied by flash filament and mass spectrographic techniques. The chief action occurs with carbon monoxide and the metals molybdenum and tantalum. Critical flash temperatures are found below which residual carbon monoxide is diminished and above which it is increased. The effect of sputtered and evaporated films of the metals on glass is also described.

G. Saini. Vedi pag. 320.

W. Schmidt. Vedi pag. 311 e 318.

H. J. Schütze and H. W. Ehlbeck (*Ulm*). – **Residual Gas Pressure in Electron Tubes.** Part II: Experimental Results (*).

Results of measurement of the residual gas pressure in electron tubes are presented. These results were obtained during the processing and the life tests of sealed-off tubes. The pressure is determined by using the electrode system of the tube itself as ionization gauge. For easy observation of the pressure variations the collector current was recorded by an automatical recorder having a sensitivity of 10^{-12} amperes per scale. The gas pressure during the getter process was studied in receiving pentodes like the EF 800, their lowest measurable gas pressure, $p_{min} = 5 \cdot 10^{-9}$ Torr, being remarkably low. Flashing the getter after sealing off the tube, the residual gas pressure even before flashing was found to be dependent on the type of the getter used, the maximum firing temperature of the getter and its temperature at sealing-off. Pressures of 10^{-6} Torr were obtained by using getters with active additives like Th, Ti and Zr. The gas pressure before flashing the getter was found to be strongly affected by the stay time of the tubes on the pump, especially if rotary pumps were used. In that case just few minutes of stay time were sufficient to increase the pressure by about 2 orders of magnitude. After flashing the Ba-getters with or without active additives in the sealed off tubes, gas pressures between $8 \cdot 10^{-6}$ and $2 \cdot 10^{-5}$ Torr were measured independent of the bulb temperature. Flashing the getter before sealing off, the residual gas pressure was affected remarkably by the stay time and by the type of the pump too. Using oil diffusion pumps low pressures of $p < 10^{-6}$ Torr were found. The gas pressure remained constant after flashing the getter until the electron current was switched on. Then the pressure was decreased due to electrical clean-up effects. The rate of clean-up was increased if the electron current and the potentials at the electron and ion collectors were raised. The pressure in receiving tubes decreased about 2 orders of magnitude during the activation process. Pressures between $5 \cdot 10^{-9}$ and 10^{-8} Torr were found during life test experiments. Under standby conditions a gradual increase of 1 to 2 orders of magnitude of the pressure was observed, corresponding to the applied heater voltages. The residual gas pressure was especially affected by the dissipated power at the plate of a power pentode or at the screen of a television picture tube.

(*) As to Part I see W. Dahlke and H. J. Schütze.

The pressure increased strongly while raising the power load of the electrodes. In the pentode PL 36 and the picture tube AW 53-88 under load final gas pressures between 10^{-7} and 10^{-6} Torr were measured during life test experiments.

H. J. Schütze. Vedi pag. 305.

N. W. W. Smith (*Salford*). – **Noise Reduction in Microwave Tubes by Getter Ion Pumping.**

The problem of ion noise in microwave oscillators and amplifiers is explained. It is shown that residual gas pressures of approx. 10^{-9} mm Hg must be maintained in order to eliminate ion noise. A description is given of the construction of an ion getter pump which is built into a backward wave oscillator and designed to operate continuously while the oscillator is in use. The problems associated with maintaining low pressures in microwave valves are discussed.

J. M. Sourdillon (*Courbevoie*). – **Emploi de getters frittés à base de zirconium.**

L'exposé concerne les conditions générales d'élaboration et quelques exemples d'application d'un getter obtenu par frittage d'un mélange de poudres d'hydrure de zirconium (80% en poids) et d'aluminium (20% en poids). Le support (de préférence en forme de goutière circulaire) est en nickel embouti ou en molybdène repoussé. On procède à une compression à froid de la poudre, directement sur son support. Les opérations de frittage ont lieu sous vide poussé: les pièces comprimées sont disposées en vrac dans un tonneau en molybdène et chauffées progressivement par induction HF. Le frittage a pour but d'une part, d'augmenter la cohésion de la substance active et son adhérence au support, d'autre part, de transformer l'hydrure de zirconium en zirconium métal à l'état amorphe. Au fur et à mesure que la température s'élève, l'aluminium se volatilise partiellement, ce qui confère à la substance, la structure poreuse recherchée. A 900° environ, se produit la décomposition de l'hydrure de zirconium qui abandonne son hydrogène. Les getters ainsi réalisés sont montés dans les tubes életroniques en lieu et place des getters ordinairement utilisés. Après la coupe du queusot, on porte les pièces à 1000 °C environ pendant plusieurs secondes afin de donner au getter sa pleine efficacité: cette opération s'effectue très commodément à l'aide d'une inductance ou d'un concentreur de champ et la forme annulaire du getter se prête particulièrement bien à ce mode de chauffage. Etant donné la grande surface de contact de la substance active (porosités) avec les gaz résiduels, une absorption par contact se produit dans de bonnes conditions. On observe de plus, dans les valves HT essayées, l'absorption dite par décharge due au fait que la recontre du flux d'électrons apparus au moment de la décharge, charge précisément les molécules gazeuses, qui viennent alors se fixer facilement sur le getter. Des essais d'application de ces getters ont été entrepris sur les valves HT EY81 et 6AX2N et sur des tubes 21B6 et 5725. Les résultats ont été très satisfaisants après 500 heures de fonctionnement. Des essais menés sur tubes de puissance de 12 kW à anode de graphite (type 3T12.000.A5) avec des getters de grandes dimensions, ont montré que le vide était maintenu dans de bonnes conditions en cours de fonction-

nement. Les getters soumis directement au rayonnement thermique de l'anode se trouvent en permanence à une température conférant à la substance une bonne activité (capacité d'absorption intéressante pour les gaz courants et en particulier pour l'oxygène). D'une façon générale, le getter n'étant pas volatilisé, mais seulement chauffé à haute température, on n'observe pas de dépôts métalliques sur les parois froides des tubes, ce qui diminue considérablement les risques de fuites électriques ou de capacités parasites. On a constaté un fonctionnement très stable. Enfin, au cours de la vie des tubes, on constate qu'il est toujours possible d'absorber les fuites virtuelles qui ont pu se produire, en chauffant simplement le getter aux environs de 950 °C pendant quelques secondes par induction HF.

J. M. Sourdillon (*Courbevoie*). – **Essai d'utilisation du titane comme fixateur de gaz.**

Parmi les métaux susceptibles de fixer les gaz résiduels des tubes électroniques après pompage et scellement, le titane présente des propriétés intéressantes, car non seulement son affinité pour les gaz courants (O_2 - CO - CO_2 - CH_4 - N_2, dans une certaine mesure H_2) est remarquable, mais de plus, ses propriétés physiques rendent aisé son emploi: point de fusion assez élévé, tension de vapeur faible jusqu'aux hautes températures, caractéristiques mécaniques suffisantes (mise en forme, rigidité à chaud etc. ...). Il a paru intéressant de faire des essais d'absorption des gaz résiduels en remplaçant dans des tubes à cathode à oxydes les getters ordinairement utilisés par des pièces en titane de forme simple. Les essais décrits concernent deux types particuliers de tubes: — un tube oscillateur subminiature expérimental, choisi en particulier en raison de son faible volume, — le tube miniature 3B4, tétrode à faisceau dirigé dont la réalisation (montage et pompage) est assez délicate, compte-tenu des performances imposées. Dans une première série d'essais, on a éliminé complètement les getters au baryum et la fixation des gaz résiduels a été assurée par la seule présence d'une anode en titane remplaçant l'anode en nickel des tubes standard. Le métal employé était le titane UT 40, non allié, des Aciéries électriques d'Ugine. La mise en forme et l'emploi des anodes en ce métal ont nécessité des traitements de recuit et de dégazage particulièrement soignés. Après pompage standard et coupe du queusot, les anodes en titane ont été chauffées par induction HF à 950 °C pendant quelques secondes, ce qui a permis de parfaire le vide. On a ensuite procédé aux traitements de stabilisation courants. On a constaté que les valeurs caractéristiques de ces tubes correspondaient en tous points aux normes du cahier des charges des tubes équipés de getter baryum et d'anode en nickel. Des tubes 3B4 montés dans les mêmes conditions (anode en titane ou getter au baryum) ont été pompés suivant la méthode standard. Après coupe du queusot, on a procédé également au chauffage de l'anode par induction HF. Après 1000 heures de fonctionnement, le vide et l'émission de ces tubes avaient pratiquement conservé leurs valeurs initiales. Dans une seconde série d'essais, on a cherché à remplacer les getters au baryum, non plus par une anode en titane, mais par une simple pièce de petites dimensions en titane UT40: petit disque en tôle de titane de 0,15 mm d'épaisseur, anneaux en fil de titane de 1 mm de diamètre. Ces pièces étaient chauffées par induction HF après pompage du tube et coupe du queusot. Après 1325 heures de fonctionnement, les tubes 3B4 essayés présentaient un bon vide et des caractéristiques correctes (émission...). Ces divers essais ont permis de constater l'efficacité du titane utilisé directement comme getter: le procédé d'activation est très souple et ne donne lieu à aucune projection métallique sur les

parois du tube, ce qui élimine un certain nombre de défauts possibles (fuites électriques interélectrodes, capacités parasites...). Les gaz résiduels paraissent fixés par le titane de façon irréversible: ainsi on a pu observer qu'il était possible d'absorber des fuites virtuelles apparues en cours de fonctionnement des tubes, par simple chauffage par induction des pièces en titane à 900-950 °C pendant quelques secondes.

F. H. Southam. Vedi pag. 304.

L. Stout. Vedi pag. 312.

H. Takayama and H. Kobayashi (*Tokyo*). – **Clean-up of Gases in TV Picture Tubes by Barium Getters.**

In this brief communication the authors present the comparative results obtained in television tubes where getters of Japanese and Italian production have been used. The measurements are carried out using the electron gun of the tube as a ionization gauge and applying the well known « gas ratio » technique normally used for pressure measurements in picture tubes. The various types of gases employed are introduced into the tube by breaking an ampoule containing a known quantity of the gas in question, which has been placed within the tube prior to its sealing. Data are given about the influence of the various gases employed on the emission from the cathode, as well as on the behaviour of the barium film after sorption of the different gases.

W. Tretner (*Darmstadt*). – **An electrostatic mass spectroscope.**

During the last few years, several methods have been known to analyse the residual gas of high vacuum devices by means of small mass spectrometer tubes. In these tubes which have a resolving power of about 20 or 30, the principle of mass separation by different times of flight is employed. Unfortunately, at pressures below 10^{-6} mm Hg, the signal currents generated by these tubes are so small that for the registration of the whole mass spectrum a comparably long time is required. In order to avoid this drawback a new mass spectrometer tube has been developed. Due to the high signal-output of this tube the whole mass spectrum, ranging from H^+ up to Hg^+, can be displayed on an oscilloscope at 50 Hz. Therefore, a practically continuous control of the residual gas can be achieved. The signal of the mass spectrometer tube is generated by a cloud of charged particles of equal relative masses which oscillates along the axis of an electrostatic field with axial symmetry. This ion cloud consists of numerous superposed elementary clouds each of which being created by an electron beam in a strong accelerating field near one end of the tube. An electrode on the other end of the tube is used to pick up the displacement-current induced by the ion cloud. The ionizing electron beam is intensity-modulated with a variable frequency. Therefore, a ion cloud is built up only when the variable modulation frequency of the beam coincides with the oscillation frequency of any sort of ions. At frequencies other than those of

the ions present in the residual gas, the elementary ion clouds cannot form one big cloud because practically no phase relation between them exists. The space-charge action of the elementary clouds explains that the functional dependence between mass intensity and partial pressure is not linear. A special tube, having a resolving power $m/\Delta m \approx 20$ at all masses, is described which can be used at pressures below $5 \cdot 10^{-5}$ mm Hg. This upper limit is set by the mean free path of the ions. The lower limit depends on the shot noise of the first amplifier stage. Thus, at a registration speed of 50 Hz, partial pressures in the order of 10^{-8} mm Hg can be detected. At still lower pressures a second operation method should be adopted which even permits the use of an electron multiplier.

J. C. TURNBULL. Vedi pag. 304.

J. v. DER WAAL. Vedi pag. 309.

J. H. N. v. VUCHT (*Eindhoven*). – **The Ceto Getter; its Chemical Structure and Hydrogen Gettering Properties.**

Ceto, which is an alloy of thorium, mischmetall and aluminium is used as a non-evaporating getter. In the course of an elaborate investigation of the ternary system Th-Ce-Al it has been proved that its crystallographic structure is of the $CuAl_2$ type, just like the closely related binary compound Th_2Al. The properties of Th_2Al, Ceto and intermediate compounds with regard to hydrogen were studied. X-ray and neutron diffraction, supplemented by nuclear magnetic resonance measurements, each at liquid nitrogen temperature, and room temperature, gave information about the structure of the reaction products. Hydrogen equilibrium pressure measurements at temperatures from 250 °C up to 700 °C gave thermodynamic information and enabled to calculate the equilibrium pressures at lower temperatures. A kinetic study, based on a simple model, of an autokatalytic sorption is reported.

R. J. WARNECKE (*Levallois-Perret*). – **Emploi du spectromètre de masse dans la technologie des tubes électroniques.**

Après avoir évoqué l'intérêt de l'emploi du spectromètre de masse pour l'étude de certains problèmes fondamentaux qui se posent dans le domaine de la technologie des tubes électroniques, l'auteur rappelle et discute les caractéristiques et les performances que doivent présenter les spectromètres susceptibles d'être utilisés dans les meilleures conditions pour l'analyse quantitative des gaz résiduels, l'étude de leurs origines et de leurs influences (en particulier sur le comportement des cathodes). Pour que les mesures soient valables il faut que la constitution interne du tube analyseur ne modifie pas la composition du gas à analyser, autrement dit qu'il n'ait pas de résiduel propre. Ceci impose que le spectromètre soit de dimensions réduites, que les effets de surface

soient aussi petits que possible, enfin que le tube puisse être énergiquement dégazé. Ces exigences excluent généralement l'utilisation des spectromètres classiques à champ secteur et limitent le choix aux spectromètres à temps de transit, ou à haute fréquence. On décrit en particulier deux types de spectromètre susceptibles d'être utilisés avec profit: l'Omégatron et l'analyseur du type Bennett. La comparaison des performances et des caractéristiques de ces deux appareils montre qu'ils ont des qualités complémentaires et que leur emploi simultané doit permettre d'effectuer les analyses envisagées, qu'il s'agisse de phénomènes statiques ou évoluant rapidement, et ce dans un domaine de pression et de masse convenable.

P. J. Whitchurch. Vedi pag. 303.

S. P. Wolsky and E. J. Zdanuk (*Waltham, Mass.*). – **The Investigation of Residual Gases in Vacuum Systems.**

A complete investigation on residual gases in electron tubes and other high vacuum systems, requires a knowledge of (1) the origin of the contaminants, (2) the partial pressure of each gas, (3) the physical state of the species, i.e., atomic, molecular, ionic, and (4) the nature of their interaction with components and walls. In an electron tube where there are hot filaments, potentials of varying magnitudes and a variety of glass and metal components, all these factors must be known in order to understand the effect of the residual gases upon tube parameters and life. The apparatus used in this work consisted of (1) an omegatron, a small volume radiofrequency mass spectrometer operating on a cyclotron resonance principle, (2) a very sensitive quartz microbalance with which weight changes of 10^{-7} grams were detected, (3) a system employing a modified Wagener technique to study getter activity, and (4) associated vacuum systems using oil, mercury, ion or cryogenic pumping. Pressures of 10^{-10} mm Hg were obtained. The combination of the vacuum microbalance and omegatron spectrometer in a single apparatus provides an extremely powerful tool with which to study outgassing, sputtering, dissociation, adsorption and oxidation phenomena over a wide range of pressures and temperatures with simultaneous identification of species evolved due to experimental procedures. Such separate investigations provide information necessary for understanding the more complex processes occurring in the electron tube. In addition to experimental apparatus and techniques, the results to be discussed concern (1) residual gases in receiving tubes; (2) residual gas content of systems pumped by different methods; (3) preliminary data on getter activity, including information on gases evolved during activation of a flashless getter; (4) impurities introduced into reagent grade gases by lubricating greases and methods of eliminating such contamination; (5) contamination due to thermal treatment and/or ion-bombardment of such materials as quartz; (6) the effect of ion-bombardment at energies up to 3 500 volts upon solid surfaces; (7) the application of the omegatron to the measurement of residual gases during manufacture processes and tube lifetime. These studies cover a broad range of interests all directed, however, to obtain the knowledge necessary to reduce to a minimum the residual gases in vacuum systems.

K. M. YAZAWA (*Tokyo*). – **Study of the Surface Structure of Barium Getter Deposited Film by an Electron Microscope.**

The rate of gas sorption of the flash-getter depends especially on whether the structure of the deposit film is in an amorphous state or not. Therefore, if we observe directly the surface structure of the deposit film as well as the measurement of the saturated value of sorption or the electrical resistivity of the deposited film, it may contribute to clarify the mechanism of sorption and to develop the method of use of a getter. The method to make the specimen and some results observed by an electron microscope are described.

E. J. ZDANUK. Vedi pag. 328.

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